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MOBILE VCE

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PAN with LOS MIMO operation

Dries Neirynck, Chris Williams, Andy Nix & Mark Beach

University of Bristol (UK)

Overview

- Because of correlation, MIMO capacity increases in LOS is not expected
- Results of measurement campaign show MIMO capacity increases in LOS despite correlation
- Previously less-known theory provides explanation
- We show how this can be used to provide MIMO capacity increases in PAN

Because of correlation, MIMO capacity increase in PAN is not expected

Decorrelated sub-channels

=

MIMO capacity increase

&

Line-of-Sight

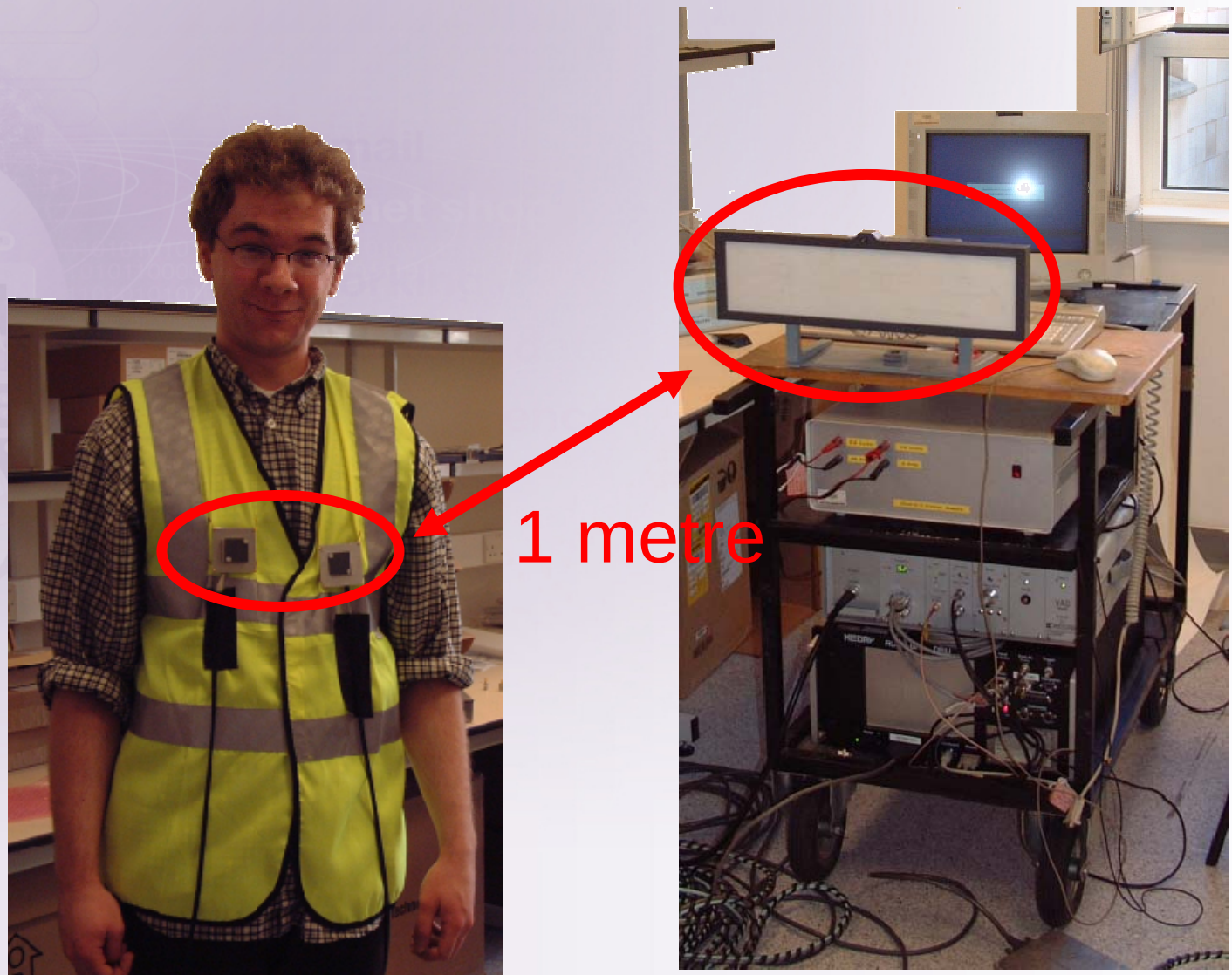
=

Correlated sub-channels

=

no MIMO capacity benefit in LOS?

Measurement with person standing in front of linear array



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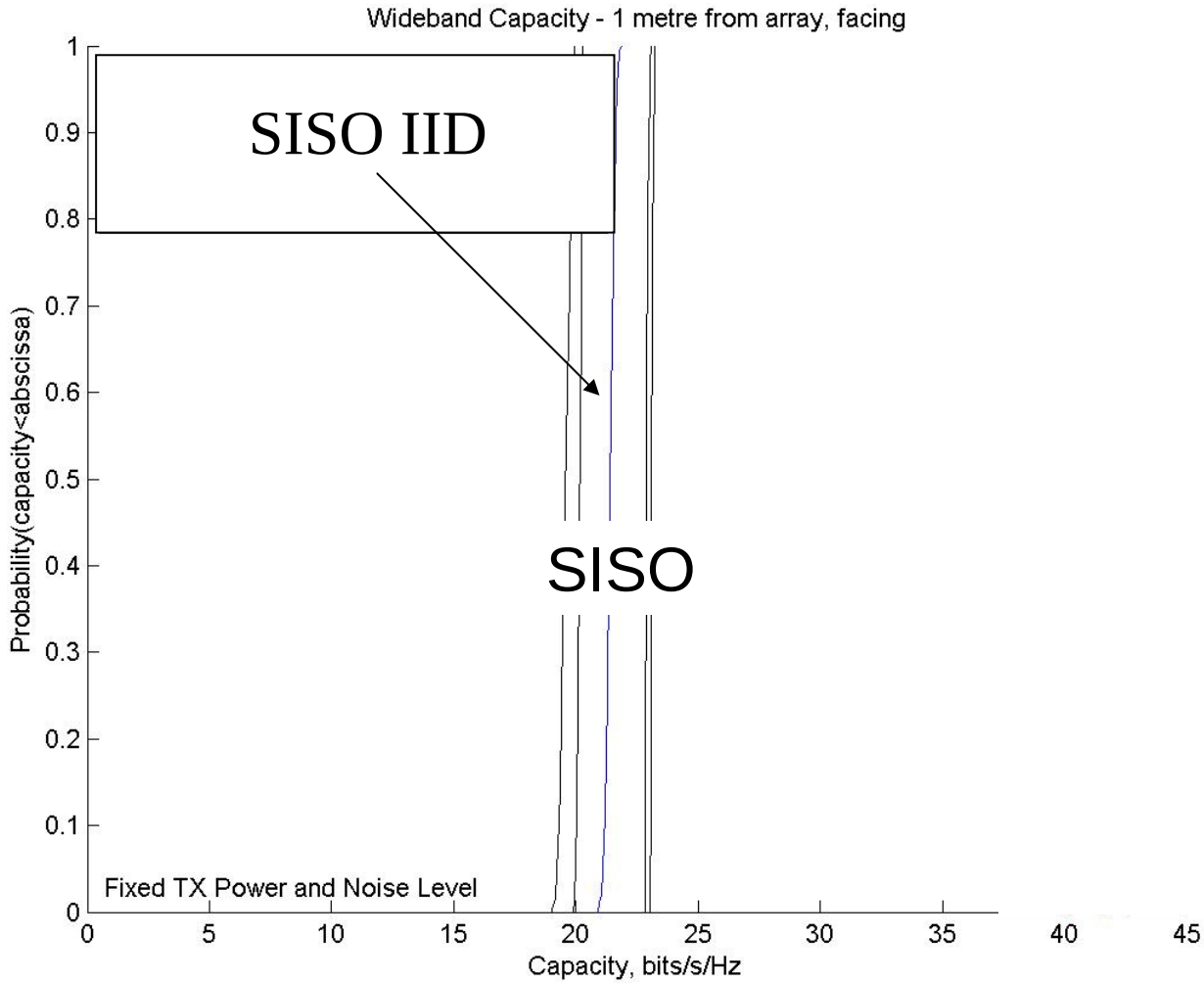
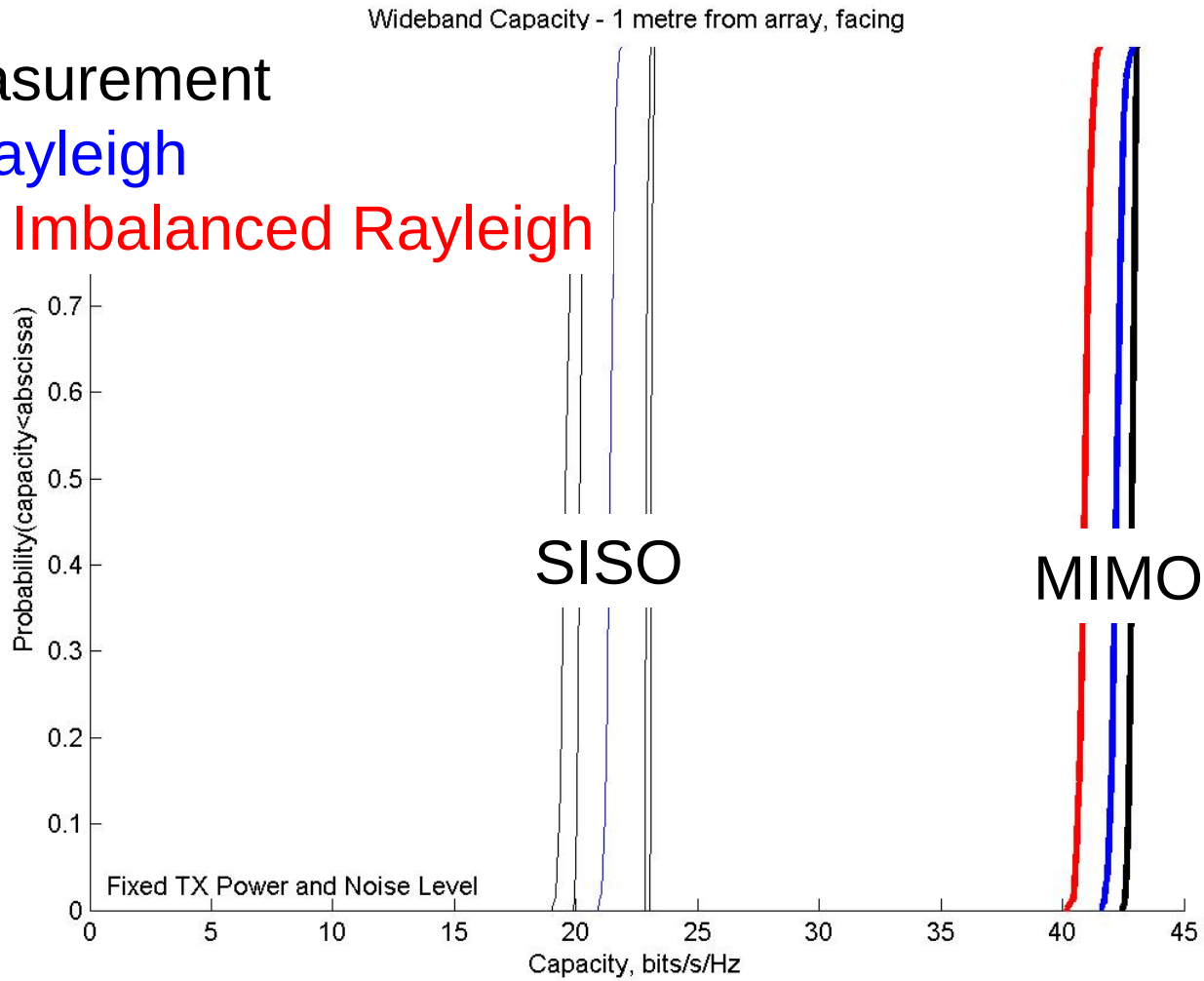
Measured SISO Capacities



Measurement shows MIMO capacity higher than IID Rayleigh despite LOS

BLACK = Measurement
BLUE = IID Rayleigh
RED = Power Imbalanced Rayleigh



Sub-channels are correlated and power varies significantly

- **Highly correlated channels:**

$$abs(R) = \begin{bmatrix} 1.0000 & 0.9726 & 0.9155 & 0.9082 \\ 0.9726 & 1.0000 & 0.9240 & 0.9666 \\ 0.9155 & 0.9240 & 1.0000 & 0.8794 \\ 0.9082 & 0.9666 & 0.8794 & 1.0000 \end{bmatrix}$$

- **Power imbalance up to 10 dB**

MIMO capacity increase comes from orthogonality in channel matrix

$$HH^{\dagger} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} h'_{11} & h'_{21} \\ h'_{12} & h'_{22} \end{bmatrix}$$

$$= \begin{bmatrix} h_{11}h'_{11} + h_{12}h'_{12} & h_{11}h'_{21} + h_{12}h'_{22} \\ h_{21}h'_{11} + h_{22}h'_{12} & h_{21}h'_{21} + h_{22}h'_{22} \end{bmatrix}$$

Determinant will be high when values on the “off-diagonal” are low.

Equivalent to demanding orthogonal channel matrix.

In LOS, deterministic phase differences can create orthogonal sub-channels

- LOS, path loss differences ignored:

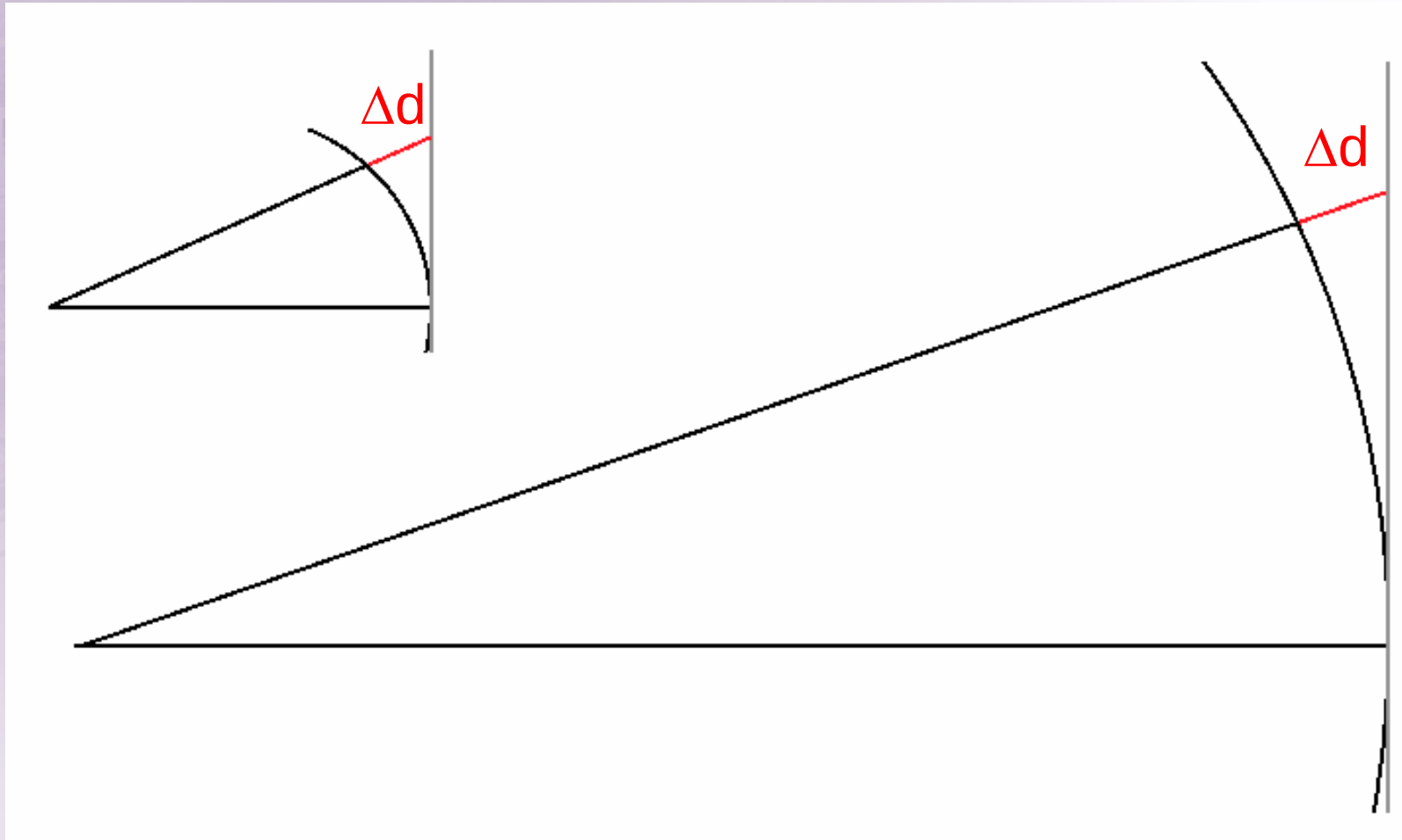
$$H = \begin{bmatrix} e^{-jkd_{11}} & e^{-jkd_{12}} \\ e^{-jkd_{21}} & e^{-jkd_{22}} \end{bmatrix}$$

- MIMO capacity proportional to determinant of

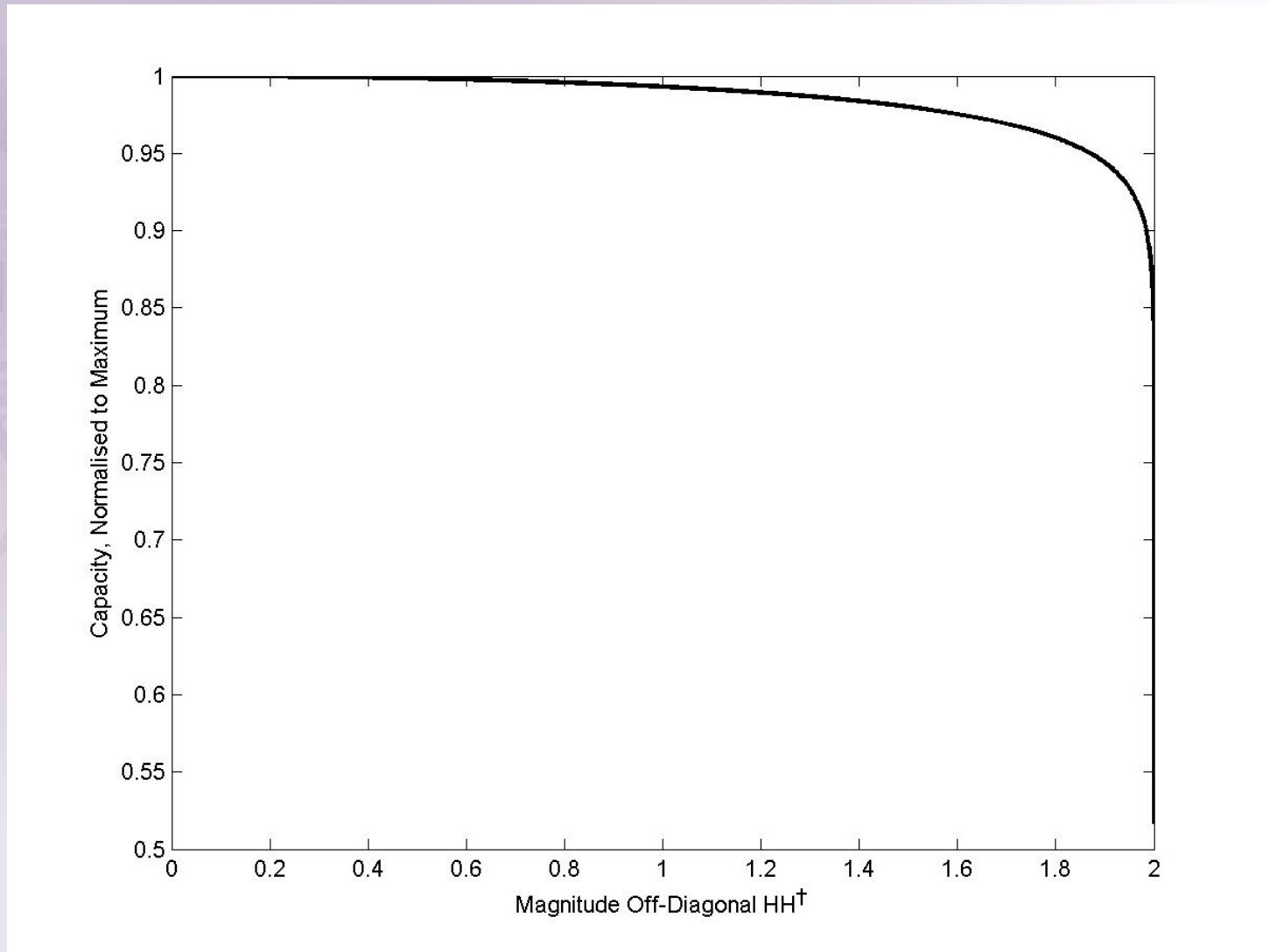
$$HH^{\dagger} = \begin{bmatrix} 2 & e^{jk(d_{21}-d_{11})} + e^{jk(d_{22}-d_{12})} \\ e^{jk(d_{11}-d_{21})} + e^{jk(d_{12}-d_{22})} & 2 \end{bmatrix}$$

- High capacity if d_{xz} such that terms on "off-diagonal" cancel out

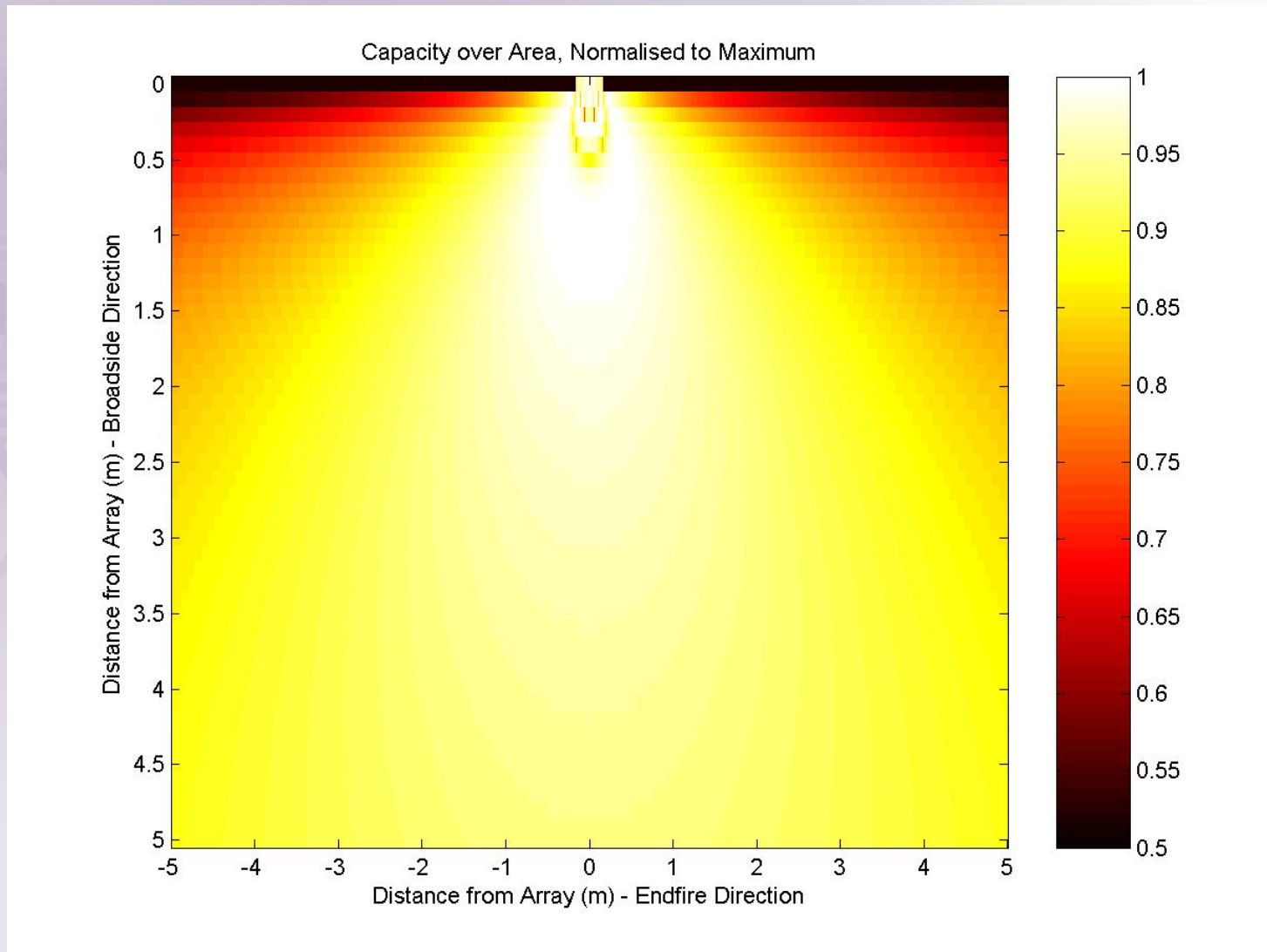
Δd: spherical wavefronts: short range and/or large antenna spacings



Because of logarithm, capacity isn't very sensitive to deviations from orthogonality



So non-ideal antenna spacings still lead to capacity increase over large area



Conclusions

- Orthogonality of channel matrix leads to MIMO capacity increases
- In LOS, the necessary phase differences can be achieved by large antenna spacings or short ranges
- Capacity is not very sensitive to deviations from orthogonality
- Example shows this can be used to provide MIMO capacity increases in PAN